



## Characterization of Sensitive Species and Habitats Affected by the Operation of USACE Water Resource Development Projects

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**PURPOSE:** This technical note is a product of the Ecosystem Management and Restoration Research Program (EMRRP) work unit titled "Reservoir Operations – Impacts on Target Species." Current knowledge regarding the occurrence of sensitive species that have been identified as a management concern in the operation of Corps projects is reviewed. The status and management of these species are examined, and species of management concern are arranged into groups based on similarities in life history characteristics and habitat requirements. These groups are further examined to identify opportunities for habitat and ecosystem-level management of sensitive species on Corps lands. Turtles and their habitats are excluded because they were addressed in a previous technical note by Dickerson, Reine, and Herrmann (1999).

**BACKGROUND:** The U.S. Army Corps of Engineers operates approximately 460 multipurpose water resource development projects in 42 states. These projects contain nearly 12 million acres of land and water resources managed for specified project purposes that can include flood control, navigation, hydropower, water supply, fish and wildlife, and recreation. Corps projects typically involve water-level management and other activities that can affect biotic communities and associated plant and animal species. Some of the plants and animals affected by project operations are considered to be sensitive species.<sup>1</sup> As used here, sensitive species include those with Federal or state legal protection status, as well as species for which there is growing concern but no current legal protection. These species are generally declining in part or all of their ranges and may be increasingly vulnerable to disturbances and habitat changes associated with land-use activities.

**METHODS:** Data for this study were acquired from two mail surveys of Corps projects. One was a survey of natural resource managers on Corps projects conducted under the Natural Resources Research Program (NRRP) in 1996. The NRRP survey was mailed to a stratified random sample of 66 Corps project management offices. Sixty-two completed questionnaires were received, a response rate of 94 percent. This survey contained a section that solicited information primarily about Federal- and state-listed species on Corps projects. Results were reported in Kasul, Martin, and Jackson (1998). Data from this study were reexamined to obtain more detailed information about the occurrence and distribution of these species on Corps projects and about the role of sensitive species management in project operations.

Species affected by the operation of Corps projects were more specifically addressed in an EMRRP survey mailed to 454 projects in 1998. The questionnaire asked each project to list all Federal- and state-listed endangered or threatened species that were of concern to project operations and management. Responses were received from 278 projects, a response rate of 61 percent. Responses were used to enumerate species by taxonomic and geographic groups. Based on these results, species were arranged into eight broad groups based on life history characteristics and habitat requirements.

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<sup>1</sup> Scientific names of species mentioned in the text are given in Appendix A.

The Institute for Water Resources (IWR) conducted an investigation of Federally listed threatened and endangered species for which the Corps has recovery responsibilities as specified in U.S. Fish and Wildlife Service (USFWS) recovery plans (Allred 1996). This study also summarized information on threatened and endangered species reported for Corps projects throughout the United States. Species data presented in Allred (1996) were used to supplement information obtained in the NRRP and EMRRP surveys.

## **SURVEY RESULTS**

**Incidence of Sensitive Species on Corps Projects.** The NRRP survey indicated that approximately 73 percent of Corps projects support one or more sensitive species. Allred (1996) similarly estimated that 312 of 456 (68 percent) Corps projects were likely to have one or more Federally listed endangered or threatened species.

Based on the NRRP survey, birds were the most frequently reported group of sensitive species (96 percent of projects having sensitive species). Other taxa were reported by a substantially smaller proportion of projects. These included invertebrates (16 percent), fishes (13 percent), plants (13 percent), mammals (7 percent), and reptiles and amphibians, hereafter referred to as herptiles (7 percent). Of 50 Federally listed species found on 62 surveyed projects, only the bald eagle<sup>1</sup> (61 percent of projects) and the peregrine falcon<sup>2</sup> (11 percent) occurred widely on Corps projects. Other listed species were typically found within a more limited geographic range and, thus, were reported on few projects.

**Current State of Knowledge.** Sixty-one percent of projects responding to the NRRP survey had initiated formal efforts to identify sensitive species. These surveys were 80 percent or more complete on only 13 percent of projects. According to the survey, only 19 percent of the projects are expected to complete 80 percent of sensitive species inventories in the next 10 years.

Efforts to identify sensitive species on Corps projects were unevenly allocated among different status categories of sensitive species. All the projects that had initiated sensitive species surveys included Federally listed species, and about three-fourths (76 percent) included Federal candidate species. Fewer projects targeted state-listed species (54 percent) or candidates for state listing (38 percent).

Efforts to identify sensitive species on Corps projects were also unevenly allocated among different taxonomic groups. Of projects that have initiated surveys for Federally listed species, approximately 83 percent included birds, but only 43-57 percent included other taxonomic groups (i.e., fishes (57 percent), invertebrates (52 percent), plants (50 percent), herptiles (45 percent), and mammals (43 percent)).

**Species Identified as a Concern to Project Operations.** Our surveys indicated that 38 percent (NRRP survey) to 40 percent (EMRRP survey) of Corps projects supporting sensitive species had management concerns related to project operations. Approximately 27 percent of projects with

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<sup>1</sup> The bald eagle was officially proposed for delisting by the USFWS on 6 July 1999.

<sup>2</sup> The peregrine falcon was officially delisted on 25 August 1999.

listed species reported concerns in regard to flood control, navigation, or hydropower operations. Twenty-four percent reported conflicts with visitor recreation, and thirteen percent had potential conflicts between sensitive species management and other natural resource management activities.

The EMRRP survey identified 70 species that affected Corps project activities (Table 1). Fifty-two (73 percent) of these were Federally listed species. The remaining 19 (27 percent) were state-listed endangered, threatened, or species of concern. Species most often identified were the bald eagle (51 projects), least tern (20), piping plover (13), osprey (9), chinook salmon (7), black-capped vireo (6), peregrine falcon (6), and Indiana bat (6). Sixty-three other species were also reported. More than half (54 percent) were reported by only 1 project. In addition, the companion survey conducted by Dickerson, Riene, and Herrman (1999) identified 25 sensitive turtle species that could potentially occur on Corps projects. These included 3 Federally listed species, 4 species proposed for Federal listing, and 18 species occurring on one or more state protection lists.

Sensitive species identified in the EMRRP survey consisted of flowering plants (15 species), birds (15), fishes (13), mussels (10), mammals (6), insects (5), herptiles (less turtles) (4), and arachnids (2). In general, a greater number of sensitive species of birds, mammals, and mussels were reported to occur on Corps projects and to influence project operations than would be anticipated from their proportional occurrence on the USFWS listing of threatened and endangered species (Table 2). This probably reflects the high proportion of riparian habitats associated with Corps projects.

From a geographic perspective, the number of species reported to affect project operations was greatest in the Southwest Division (22); followed by Northwest, and Great Lakes and Ohio River (18 each); South Atlantic (12); Mississippi Valley (10); North Atlantic (9); and South Pacific (5) Divisions (Table 3). The bald eagle was the most frequently reported species in four Divisions and the second-most-frequently reported species in two others. The osprey was the most frequently reported species in two Divisions.

**STATUS AND MANAGEMENT OF SENSITIVE SPECIES:** Approximately 79 percent of species identified as a concern in project operational activities were Federally listed species. The predominance of Federally listed species was anticipated because their protection is mandated under Federal law. However, approximately 21 percent of the species reported to affect project activities are not Federally protected. These species appear to be about equally divided between those with state protection and those of special concern that lack formal legal protection, either state or Federal. Two state-listed species, the osprey (reported by nine projects) and the paddlefish (five projects) were among the most frequently reported species affecting project activities.

Although listed in Allred (1996), Brady and Gordon (1994), and other sources, some species known to be a concern to Corps project operations were not identified in the EMRRP survey. These include the least Bell's vireo, roseate tern, southwestern willow flycatcher, California clapper rail, wood stork, cerulean warbler, trumpeter swan, salt marsh harvest mouse, southeastern myotis, American black bear, southeastern beach mouse, Concho water snake, and valley elderberry longhorn beetle. Most of these species appear to be a concern on projects that did not respond to the EMRRP survey. Brady and Gordon (1994) provided information on additional state and Federally listed plant species that potentially occur on project lands.

**Table 1**  
**Sensitive Species Reported to be of Concern to Operational Activities on Corps Projects<sup>a,b</sup>**

Species	No. Projects	Species	No. Projects
<b>Plants</b>		<b>Fishes (cont.)</b>	
Ute ladies' tresses	3	Paddlefish <sup>c</sup>	5
Hyssop-leaved fleabane <sup>c</sup>	2	Sockeye salmon	5
Relict trillium	2	Steelhead	5
Texas prairie dawn-flower	2	Coho salmon	4
Earth fruit	2	Leopard darter	4
Eastern prairie fringed orchid	1	Pallid sturgeon	2
Golden club <sup>c</sup>	1	Bluebreast darter <sup>c</sup>	1
Great Plains ladies'-tresses <sup>c</sup>	1	Cutthroat trout	1
Navasota ladies'-tresses	1	Neosho madtom	1
Pink lady's slipper <sup>c</sup>	1	Topeka shiner	1
Spring Creek bladderpod	1	White sturgeon	1
Stones River bladderpod <sup>c</sup>	1		
Tennessee purple coneflower	1	<b>Herptiles</b>	
Virginia spirea	1	Eastern massasauga rattlesnake <sup>c</sup>	2
Yellow lady's slipper <sup>c</sup>	1	Eastern indigo snake	1
		Giant garter snake	1
		Houston toad	1
<b>Arachnids</b>		<b>Birds</b>	
Bee Creek Cave harvestman	1	Bald eagle	51
Bone Cave harvestman	1	Least tern	20
		Piping plover	13
<b>Invertebrates – insects</b>		Osprey <sup>c</sup>	9
American burying beetle	3	Black-capped vireo	6
Cobblestone tiger beetle <sup>c</sup>	1	Peregrine falcon	6
Coffin Cave mold beetle	1	Golden-cheeked warbler	5
Kretschmarr Cave mold beetle	1	Red-cockaded woodpecker	4
Tooth Cave ground beetle	1	Whooping crane	4
Valley elderberry longhorn beetle	1	American white pelican <sup>c</sup>	3
		Burrowing owl <sup>c</sup>	1
<b>Invertebrates – mussels</b>		Crested caracara	1
Brook floater mussel <sup>c</sup>	2	Everglades snail kite	1
Clubshell	2	Red-shouldered hawk <sup>c</sup>	1
Eastern pearlshell <sup>c</sup>	2	Trumpeter swan <sup>c</sup>	1
Cumberland bean	1		
Cumberlandian combshell	1	<b>Mammals</b>	
Dwarf wedgemussel	1	Indiana bat	6
Little-wing pearlymussel	1	Gray bat	3
Northern riffleshell	1	Preble's meadow jumping mouse	3
Ouachita rock-pocketbook mussel	1	River otter <sup>c</sup>	2
Oyster mussel	1	Rafinesque's big-eared bat <sup>c</sup>	1
		West Indian manatee	1
<b>Fishes</b>			
Chinook salmon	7		
Bull trout	5		

<sup>a</sup> Results of the EMRRP survey of 455 Corps projects in which 278 responded and 111 reported species that affected project operations.

<sup>b</sup> Denotes state-listed or watchlist species; all others are Federally listed as endangered or threatened.

<sup>c</sup> Gopher tortoise was reported by one project, but was excluded here because turtles were addressed in a survey by Dickerson, Reine, and Hermann (1999).

**Table 2**  
**Comparison of Taxonomic Distribution of Federally Listed Species in the United States and on Corps Projects**

Taxonomic Group	Percent Distribution		
	All Federal T&E Species <sup>a</sup>	Federal T&E Species on Corps Projects <sup>b</sup>	Species of Concern to Operations <sup>c</sup>
Flowering plants	56.7	20.0	21.1
Fishes	9.3	12.0	18.3
Birds	7.8	18.0	21.1
Clams	6.0	32.0	14.1
Mammals	5.8	10.0	8.5
Herptiles	4.5	6.0	7.0
Insects	3.2	2.0	7.0
Nonflowering plants	2.7	0	0
Snails	1.9	0	0
Crustaceans	1.7	0	0
Arachnids	0.4	0	2.8
<b>Total</b>	<b>100.0</b>	<b>100.0</b>	<b>99.9</b>

<sup>a</sup> Computed from USFWS box scores of 1,154 threatened and endangered species updated 30 September 1998.

<sup>b</sup> Computed from 50 Federally listed threatened and endangered species identified in a 19-percent random sample of Corps projects in which there was 94-percent response rate.

<sup>c</sup> Computed from 70 sensitive species identified in a survey of all Corps projects in which there was a 61-percent response rate.

Species of concern reported for Corps projects are proportionally different than the overall listing of Federally protected species (Table 2). Flowering plants, which account for more than half (56 percent) of Federally listed species, account for only 20 percent of sensitive species found on Corps projects and 21 percent of sensitive species known to be a concern in project operations. Several other taxonomic groups, notably birds, mussels, fishes, and mammals had greater proportional occurrence on Corps projects than on the Federal threatened and endangered species list.

Habitat, detectability, and level of inventory effort are three factors that likely influence the types of species documented as occurring on Corps projects. Most projects occur along major waterways and have extensive areas of aquatic and riparian habitat. As a result, sensitive species that utilize these types of habitats (primarily fishes, mussels, and birds) tend to occur more frequently on Corps projects, and more often become a factor in project operational activities. Detectability is important because species that are solitary, secretive, exceedingly rare, or difficult to recognize may avoid detection, while those that are highly visible or otherwise easily detected are more likely to be reported. Thus, birds, fishes, and large mammals are more likely to have been documented on Corps projects. The level of inventory effort that has been directed toward species detection is also important. On Corps projects, species inventories are more extensive and complete for birds than for any other group, and inventories appear to be least complete for plants. This may partly explain why birds and plants, respectively, are over- and under-represented on Corps lands compared to their proportional occurrence as Federally listed species.

**Table 3**  
**Geographic Distribution of Selected Sensitive Species Reported of Concern to Operational Activities on Corps Projects**

Division	Number of Projects			No. of Different Species Reported	Most Commonly Reported Species (No. Projects Reporting this Species)
	Surveyed	Responded	Reported One or More Species		
Great Lakes and Ohio River	127	84	22	18	Osprey (6), Bald eagle (5), Paddlefish (5), Clubshell (2), Gray bat (2), Indiana bat (2)
Mississippi Valley	49	21	9	10	Bald eagle (9), Indiana bat (4)
North Atlantic	50	25	10	9	Osprey (3), Bald eagle (2), Brookfloater mussel (2), Eastern pearlshell (2), Hyssop-leaved fleabane (2)
Northwest	78	57	26	18	Bald eagle (13), Least tern (11), Chinook salmon (10), Bull trout (5), Sockeye (5), Steelhead (5), Peregrine falcon (4), American white pelican (3), Coho salmon (3), Preble's jumping mouse (3), Ute ladies' slipper (3), Whooping crane (3), Pallid sturgeon (2)
South Atlantic	27	25	13	12	Bald eagle (11), Relict trillium (2)
South Pacific	34	14 <sup>a</sup>	4 <sup>a</sup>	5	No species reported more than once <sup>a</sup>
Southwest	89	52	28	22	Bald eagle (10), Least tern (9), Black-capped vireo (6), Golden-cheeked warbler (5), Leopard darter (4), American burying beetle (3), Peregrine falcon (2), Red-cockaded woodpecker (2), Texas prairie dawn-flower (2)
Total	454	278	112		

<sup>a</sup> Not considered to be an adequate sample.

Proactive management must anticipate discovery of sensitive species that have not yet been identified on Corps projects, as well as changes to the status of existing species occurring on project lands. The actual number of sensitive plant and animal species that occur on Corps projects is almost certainly greater than the number that have been discovered to date. Other species are likely to be discovered as progress is made toward completion of project plant and animal inventories in general, and endangered and threatened species surveys in particular. Thus, projects will likely continue to face new challenges associated with management of sensitive species.

Efforts to manage sensitive species are evolving from single-species to multi-species and habitat-based approaches that emphasize the preservation and restoration of critical habitats and entire communities (Bloomgarden 1995, Tear et al. 1995, Martin et al. 1996). Habitat-based management approaches may simultaneously benefit both identified and unidentified sensitive species on Corps project lands. Thus, habitat-based approaches can proactively address sensitive species concerns

even when sensitive species have not been completely inventoried and are, therefore, only partially known (Dobson et al. 1997, Carroll et al. 1996).

**TREATMENT OF SPECIES GROUPS:** The potential for multi-species and habitat-based management of sensitive species on Corps projects was assessed by organizing sensitive species into groups that exhibit characteristics that can be broadly used as a basis for multi-species and habitat-based management. Species identified by project personnel and other sources as a concern in project operations were grouped into eight broad categories based on species similarities in life history and habitat utilization (Table 4). Species within some groups share taxonomic and geographic similarities, while the species comprising other groups are taxonomically and geographically diverse but have life histories and habitat requirements that may allow opportunities for similar management approaches with respect to project operations.

**Table 4**  
**General Habitat/Life History Categories of Sensitive Species Known to be of Concern in Corps Project Operations**

Category	Taxon	Species
Riverine (sessile)	Mussels	Brook floater mussel, Clubshell, Eastern pearlshell, Cumberland bean, Cumberlandian combshell, Dwarf wedge mussel, Little-wing pearlymussel, Northern riffleshell, Ouachita rock-pocketbook mussel, Oyster mussel
Riverine (mobile)	Fishes	Bluebreast darter, Bull trout, Cutthroat trout, Leopard darter, Neosho madtom, Topeka shiner
Riverine (migratory)	Fishes	Chinook salmon, Coho salmon, Paddlefish, Pallid sturgeon, Sockeye salmon, Steelhead, White sturgeon
Riparian generalists	Mammals Birds Plants	American black bear, bats (see cave-users) Bald eagle, osprey, Peregrine falcon, Red-shouldered hawk Relict trillium
Riparian specialists	Mammals Birds Herptiles Plants	Preble's jumping mouse, river otter Least Bell's vireo, Least tern, Piping plover, Southwestern willow flycatcher Concho water snake Navasota ladies' tresses, Spring Creek bladderpod, Stone River bladderpod, Virginia spirea
Wetland	Mammals Birds Herptiles Plants	Salt marsh harvest mouse American white pelican, California clapper rail, Everglades snail kite, Roseate tern, Trumpeter swan, Whooping crane Giant garter snake, Concho water snake, Houston toad Fringed prairie orchid
Upland	Mammals Birds Herptiles Plants	American black bear, bats (see cave-users) Black-capped vireo, Burrowing owl, Cerulean warbler, Crested caracara, Golden-cheeked warbler, Red-cockaded woodpecker Eastern indigo snake, Eastern massasauga rattlesnake, Giant garter snake, Houston toad Tennessee purple cone flower, Relict trillium (in mature hardwoods)
Cave-users	Mammals Arachnids Insects	Rafinesque's and Townsend's big-eared bats, Gray bat, Indiana bat, Southeastern myotis (most species may use caves, crevices, and/or tunnels seasonally but also occur in riparian and upland forests) Bee Creek Cave harvestman, Bone Cave harvestman Coffin Cave mold beetle, Kretschmarr Cave mold beetle, Tooth Cave ground beetle

Future technical notes will be provided on species groups, their habitat characteristics, and potential impacts associated with Corps project operations. The emphasis of these reports will be on upland species, cave-users, wetland species, riparian generalists, and riparian specialists. Aquatic groups (sessile riverine species, migratory riverine species, and mobile riverine species) are covered in other EMRRP work units and are beyond the scope of this study. The categories and species associated with each group were constructed from existing information and are subject to revision as new information becomes available. Also, several sub-groups, and even group combinations, likely will be developed for presentation as technical notes. For example, a note is being prepared on eastern cave bats that may also be characterized as riparian generalists. Species groups are generally characterized below.

**Sessile riverine species.** All species of concern in this group are mussels. Included are 9 of 16 (56 percent) Federally listed clams and mussels and one state-listed species listed as threatened in Vermont. All of the Federally listed species of concern on Corps projects occur in the western Appalachian rivers, particularly in Alabama, Georgia, Kentucky, and Tennessee.

**Migratory riverine species.** This group consists primarily of fish species that undertake seasonal or life-stage migrations. It includes anadromous salmonids occurring in west coast rivers that empty into the Pacific Ocean, and sturgeon in the Missouri/Mississippi River drainage and coastal U. S. rivers draining into the Gulf of Mexico. Atlantic coast sturgeon were not identified by projects as a concern; however, at least one instance of navigation project delays is known to have occurred because of issues regarding Atlantic coast sturgeon (Killgore and Chan 1996). Species in this group are potentially vulnerable to the effects of water management activities associated with flood control, navigation, and hydroelectric projects. Concerns regarding sturgeon are exacerbated by a lack of basic life history data, especially information about spawning and rearing.

**Mobile riverine species.** This group is comprised mainly of nonmigratory fishes. It includes nonmigratory salmonids found in montane regions of the western United States. In some instances only certain populations associated with particular river systems are of concern. This group also includes various nonmigratory species of fishes found primarily in the eastern half of the United States. These often have limited geographical ranges and/or habitat requirements associated with aquatic habitat features that are uncommon within their range.

**Cave users.** These are terrestrial species that typically use caves or cave-like structures. Nine cave-using species have been reported as species of concern in project operations. They include two species of spiders, three species of beetles, and four species of bats. Cave-using species were reported to be a concern primarily in the Southwest and the Great Lakes and Ohio River Divisions where cave formations occur on or near Corps projects. These species may also be a concern elsewhere, particularly in the South Atlantic Division where cave habitat can be found near Corps projects. Protection of caves and surrounding habitats is a primary concern associated with the management of these species.

**Upland species.** This group consists of species associated with the Corps-managed ribbon of terrestrial habitats surrounding the project river reach or reservoir. These habitats are primarily woodlands or grasslands and may vary regionally and/or locally from moist to dry (or arid). This



group has mammal, bird, herptile, and plant representatives. Many of these species have a limited geographic range and, hence, are found on only a few projects. However, as a group they are widely distributed and are therefore a concern on many projects.

**Wetland species.** This group consists primarily of bird and plant species that depend on wetlands associated with rivers and their estuaries. These habitats include freshwater and coastal marshes, wet prairies, and periodically inundated bottomland hardwoods. Species of concern in this group include wetland-dependent mammals, birds, herptiles, and plants. Many of the bird species are seasonal residents on project wetlands.

**Riparian generalists.** This group comprises species typically found in riparian zones; however, some species are wide-ranging and may seasonally utilize adjacent transitional or upland habitats. Some species in this group may follow rivers or seacoasts during migration. Neotropical migrant birds in this category will use riparian and upland habitats but tend to concentrate in riparian zones, especially in the West.

**Riparian specialists.** This group consists of species that are closely associated with water courses, often with streambanks or flood zones that are regularly inundated. Riparian specialists include mammal, bird, herptile, and plant species. There is considerable regional variation in the way these species use riparian habitats, but all are associated with particular and sometimes localized habitat types.

**IMPLICATIONS FOR HABITAT-BASED MANAGEMENT:** An important consideration in habitat-based management of sensitive species is the spatial scale required for effective management. At one end of the scale are species that have specific habitat requirements that can be satisfied on a small spatial scale. They include some cave-users, riparian specialists, sessile aquatic species, and many sensitive plants. These groups can often be managed effectively by protecting existing habitat or restoring degraded habitats, particularly where critical areas are small and isolated. For several of these groups, habitat-based management can simultaneously address the needs of multiple species.

The other end of the spatial scale is characterized by sensitive species that are highly mobile and have broad habitat requirements, such as riparian generalists and migratory riverine species. These species may utilize or require multiple habitats over large areas within a riparian zone to support feeding, breeding, and migration requirements. The minimum habitats needed to support life requirements for these species can extend outside project boundaries so that successful management may require cooperative efforts among managers from several land management jurisdictions. Therefore, habitat-based management approaches are fundamentally more complex because they must incorporate a larger spatial scale that will involve cooperation among various offices and agencies.

Corps projects typically incorporate a terrestrial and riparian buffer around the primary water body to protect the shoreline from development and other potentially adverse changes. This buffer zone can support a rich diversity of transitional and upland species. Upland species are less directly affected by traditional water-level operations than other groups, but are still affected by recreation and natural resource management activities that occur on projects.

Due to the spatial configuration of Corps projects, Corps-managed landscapes typically have a long project border relative to available habitat area. Results of the NRRP survey suggest that management of sensitive species in transitional and upland habitats has great potential for being adversely affected by land use changes occurring along the project boundary that result in overall habitat reduction and fragmentation (Kasul, Martin, and Jackson 1998). As a result, successful management of sensitive species is likely to require cooperative management efforts between the project and neighboring land owners.

Many species having life requirements that can be satisfied on a small spatial scale may be managed by project personnel using habitat-based methods. However, migratory fishes, riparian generalists, and upland species potentially affected by changing land uses along project boundaries are more likely to require a regional land management approach involving partnerships among Corps and non-Corps land management jurisdictions. For these species, ecosystem management of regional watersheds may be needed in addition to habitat-based management of Corps resources. This might be accomplished by incorporating sensitive species management into an overall ecosystem management framework such as the one described in Environmental Regulation 1130-2-540 (U.S. Army Corps of Engineers 1996). This may offer the best long-term approach to providing greater flexibility in achieving project operational goals while meeting sensitive species management obligations.

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[www.wes.army.mil/el/emrrp](http://www.wes.army.mil/el/emrrp)

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## Appendix A Scientific Names of Species Mentioned in Tables and Text of this Report

Common Name	Scientific Name	Common Name	Scientific Name
<b>Plants</b>		<b>Fishes (cont.)</b>	
Earth fruit	<i>Geocarpum minimum</i>	Sockeye salmon	<i>Onchorynchus nerka</i>
Eastern prairie fringed orchid	<i>Platanthera leucophaea</i>	Steelhead	<i>Onchorynchus mykiss</i>
Golden club	<i>Orontium aquaticum</i>	Topeka shiner	<i>Notropis topeka</i>
Great Plains ladies'-tresses	<i>Spiranthes magnicamporum</i>	White sturgeon	<i>Acipenser transmontanus</i>
Hyssop-leaved fleabane	<i>Erigeron hyssopifolius</i>		
Navasota ladies'-tresses	<i>Spiranthes parksii</i>	<b>Herptiles</b>	
Pink lady's slipper	<i>Cypripedium acaule</i>	Concho water snake	<i>Nerodia paucimaculata</i>
Relict trillium	<i>Trillium reliquum</i>	Eastern indigo snake	<i>Drymarchon corais couperi</i>
Spring Creek bladderpod	<i>Lesquerella perforata</i>	Eastern massasauga	<i>Sistrurus catenatus catenatus</i>
Stones River bladderpod	<i>Lesquerella stonensis</i>	rattlesnake	
Tennessee purple coneflower	<i>Echinacea tennesseensis</i>	Giant garter snake	<i>Thamnophis gigas</i>
Texas prairie dawn-flower	<i>Hymenoxys texana</i>	Gopher tortoise	<i>Gopherus polyphemus</i>
Ute ladies' tresses	<i>Spiranthes diluvialis</i>	Houston toad	<i>Bufo houstonensis</i>
Virginia spirea	<i>Spirea virginiana</i>		
Yellow lady's slipper	<i>Cypripedium calceolus</i>	<b>Birds</b>	
<b>Arachnids</b>		American white pelican	<i>Pelicanus erythrorhynchos</i>
Bee Creek Cave harvestman	<i>Texella reddelli</i>	Bald eagle	<i>Haliaeetus leucocephalus</i>
Bone Cave harvestman	<i>Texella reyesi</i>	Black-capped vireo	<i>Vireo atricapillus</i>
<b>Invertebrates – insects</b>		Burrowing owl	<i>Speotyto cunicularia</i>
American burying beetle	<i>Nicrophorus americanus</i>	California clapper rail	<i>Rallus longirostris obsoletus</i>
Cobblestone tiger beetle	<i>Cicindela marginipennis</i>	Cerulean warbler	<i>Dendroica cerulea</i>
Coffin Cave mold beetle	<i>Batrissodes texanus</i>	Crested caracara	<i>Caracara plancus</i>
Kretschmarr Cave mold beetle	<i>Texamaurops reddelli</i>	Everglades snail kite	<i>Rostrhamus sociabilis plumbeus</i>
Tooth Cave ground beetle	<i>Rhadine persephone</i>	Golden-cheeked warbler	<i>Dendroica chrysoparia</i>
Valley elderberry longhorn beetle	<i>Desmocerus californicus dimorphus</i>	Least Bell's vireo	<i>Vireo bellii pusillus</i>
<b>Invertebrates – mussels</b>		Least tern	<i>Sterna antillarum</i>
Brook floater mussel	<i>Alasmidonta varicosa</i>	Osprey	<i>Pandion haliaetus</i>
Clubshell	<i>Pleurobema clava</i>	Peregrine falcon	<i>Falco peregrinus</i>
Cumberland bean	<i>Villosa trabalis</i>	Piping plover	<i>Charadrius melodus</i>
Cumberlandian combshell	<i>Epioblasma brevidens</i>	Roseate tern	<i>Sterna dougalli dougalli</i>
Dwarf wedgemussel	<i>Alasmidonta heterodon</i>	Red-cockaded woodpecker	<i>Picoides borealis</i>
Eastern pearlshell	<i>Margaritifera margaritifera</i>	Red-shouldered hawk	<i>Buteo lineatus</i>
Little-wing pearlymussel	<i>Pegias fabula</i>	Southwest willow flycatcher	<i>Empidonax traillii extimus</i>
Northern riffleshell	<i>Epioblasma torulosa rangiana</i>	Trumpeter swan	<i>Cygnus buccinator</i>
Ouachita rock-pocketbook mussel	<i>Arkansia wheeleri</i>	Whooping crane	<i>Grus americana</i>
Oyster mussel	<i>Epioblasma capsaeformis</i>	Wood stork	<i>Mycteria americana</i>
<b>Fishes</b>		<b>Mammals</b>	
Bluebreast darter	<i>Etheostoma camurum</i>	American black bear	<i>Ursus americanus</i>
Bull trout	<i>Salvelinus confluentus</i>	Rafinesque's big-eared bat	<i>Corynorhinus rafinesquii</i>
Chinook salmon	<i>Onchorynchus tshawytsch</i>	Townsend's big-eared bat	<i>Corynorhinus townsendii (ingens &amp; virginianus)</i>
Coho salmon	<i>Onchorynchus kisutch</i>	Gray bat	<i>Myotis grisescens</i>
Cutthroat trout	<i>Onchorynchus clarkii</i>	Indiana bat	<i>Myotis sodalis</i>
Leopard darter	<i>Percina pantherina</i>	Preble's meadow jumping mouse	<i>Zapus hudsonius preblei</i>
Neosho madtom	<i>Noturus placidus</i>	River otter	<i>Lutra canadensis</i>
Paddlefish	<i>Polyodon spathula</i>	Salt marsh harvest mouse	<i>Reithrodontomys raviventris</i>
Pallid sturgeon	<i>Scaphirhynchus albus</i>	Southeastern beach mouse	<i>Peromyscus polionotus niveiventris</i>
		Southeastern myotis	<i>Myotis austroriparius</i>
		West Indian manatee	<i>Trichechus manatus</i>